CAD Tools for Antennas

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***Abstract* — There are a number of CAD tools available in the market today for microwave designs. They enable the designer to try his hand at even very complex design very easily and quickly. They optimize MEMS designs prior to fabrication, which reduces prototype development cycle time and cuts manufacturing costs. This paper attempts to list a few of the popular CAD tools that are available in the market today and highlights on their special features that makes each tool unique.**

***Index Terms* — CAD Tools, MOM, FEM, FDTD, Intellisuite, Coventorware, IE3D.**

I.INTRODUCTION

MEMS designs are complex in geometry and physics. CAD tools allow design exploration before committing to prototype as a result of which it takes faster time to market. They also reduce time and cost of trial and error as the results obtained more accurate. Another advantage is that the design can be documented and reused.

CAD tools employ one or more of the following techniques to simulate the design and provide results:

1) Method of moments
2) Finite element method
3) Finite difference time domain

Method of moments is the method for solving problems where the fields depend on 3 space dimension, while their sources (currents) are confined planes with 2 space dimensions. Typical geometries which can be solved using MoM techniques are microstrip circuits, coplanar circuits, patch antennas and general multi-layer structures.Finite element and FDTD are the methods for solving problems where both the field and the source functions depend on three space dimensions. This comprises all volumic full-wave general purpose formulations.None of the numerical methods are capable of solving all the electromagnetic modelling problems. These are limited by the availability of pc memory, pc run time or the numerical model can simply not be applied to the structure at hand.i.e., MoM is not applicable to structures with inhomogeneous or non-linear dielectrics and enclosures of complex shapes. FDTD is difficult to implement when fine geometrical detail must be resolved within a structure of large dimensions. Finite Element Method cannot efficiently model large open radiation and scattering problems because of the large computational space that would have to be discretized.

II.CAD TOOLS

Some of the most widely used CAD tools for the design of antennas are discussed in detail

.A.IntelliSuite

IntelliSuite starts the design process from fabrication machine settings, rather than device geometry — an approach that helps create highly accurate models. In turn, this demonstrates that device geometry and behavior are a direct result of process conditions.IntelliSuite comes standard with completely coupled electrical, piezo-electrical, mechanical and thermal analysis tools for executing linear or non-linear static or transient analysis, while optional modules for electromagnetic, fluidic and system analysis are also available.It is based upon a unique combination of the best of bottom up process-driven design and top down synthesis. Top down methodology allows one to quickly explore a wide range of design options, while bottom up design provides the accuracy to produce first-time right silicon.IntelliSuite features a comprehensive material database, which allows one to understand material properties like conductivity, film stresses and mechanical strength as a function of processing parameters.IntelliSuite takes the complexity out of meshing. Automatic meshing tools can generate near- optimal meshes while interactive tools allow further refinement of the meshes. IntelliSuite permits switching from automatic to manual gears design time and minimize the learning curve. IntelliSuite is designed to be an open system that's compatible with other tools. Its macro-models can be used in conjunction with SPICE, SPECTRE or other tools for further system integration. All of the analysis results and solid models can be exported to AVI or JPG format to enhance the next presentation or report. In addition, all of its file formats are rigorously documented and available, which means that, like other tools on the market, vendor lock-in is never an issue.

B.COVENTORWARE

Coventor's hybrid approach combines system level modeling and finite element modeling. CoventorWare products are available separately or bundled in various configurations to conform to the customer's preferred design flow, methodology and application. CoventorWare consists of four main modules that may be used stand-alone or integrated into a complete design flow:

978-1-4244-2690-4444/08/$25.00©2008 IEEE

ARCHITECT	Tool for simulating complex MEMS devices and MEMS based products
DESIGNER	MEMS and Microfluidics Geometry Processor
ANALYZER	Design Verification Using 3D Numerical Analysis
INTEGRATOR	Model complex dynamic properties and export reduced order macro models

C.IE3D

IE3D is a product of ZELAND SOFTWARE INC. It is a MoM-based EM Simulator solving the current distribution on 3D and multilayer structures of general shape. It has been widely used in the design of MMICs, RFICs, LTCC circuits

The benfits of using IE3D for simulation can be understood from its unique features. It has high efficiency, high accuracy and low cost with Windows based graphic interface that allows interactive construction of 3D and multilayer metallic structures as a set of polygons. Numerous editing capabilities are implemented to ease the construction and manipulation of polygons and vertices. It also has a built-in library for construction of complicated structures.

The primary simulation results of IE3D are the parameters S. The S parameters
can optionally converted into a spice netlist. The spice netlist could be imported into a spice simulator for time-domain simulation.

D.FIDELITY

FIDELITY is a FDTD (Finite-Difference Time-Domain) based Full-3D EM Simulator for modeling microwave circuits, components, and antenna, wireless/RF antennas, EMC and EMI structures, and other high-speed and high-frequency circuitry. FIDELITY has several attractive features which include non-uniform mesh for modeling planar and 3D structures with complicated dielectric configuration. Users are not limited to the mesh. The mesh can be adjusted to fit a geometry. It has an MS-Windows based, menu-driven graphic interface for interactive construction of planar and 3D structures as objects. It has strong geometry editing and checking capability. It also provides multiple 2D and 3D views for better visual understanding of the structures in editing.

3D Structure E-Field H-Field

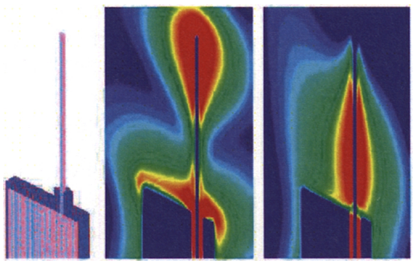

Figure1. A plastic-coated cellular handset modeled on FIDELITY

It provides hassle-free port definition. It can perform radiation pattern calculation, calculation of antenna directivity, gain, efficiency and other parameters. The package includes the Pattern View for pattern displays and comparison. A notable feature is 3D electric field, magnetic field and Poynting vector display with slicing capability as shown in the figure.

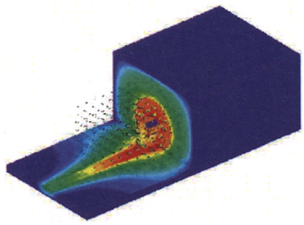

Figure2. Poynting vector and near field display on a microstrip to coaxial transition.

E.HFSS

It is the industry-standard software for S-parameter and full-wave SPICE extraction and for the electromagnetic simulation of high-frequency and high-speed components. The US company Ansoft is the society which commercialises this software. HFSS is widely used for the design of on-chip embedded passives, PCB interconnects, antennas, RF/microwave components, and high-frequency IC packages. HFSS utilizes a 3D full-wave Finite Element Method (FEM) to compute the electrical behavior of high-frequency and high-speed components. With HFSS, engineers can extract parasitic parameters (S, Y, Z), visualize 3D electromagnetic fields (near- and far-field), generate broadband SPICE models, and optimize design performance.

HFSS employs techniques such as automatic mesh generation and refinement, tangential vector finite elements, and Adaptive Lanczos Pade Sweep (ALPS). Accuracy of simulation results is assured because the software automatically computes multiple adaptative solutions until a user –defined convergence criterion is met.

F.Cadence

The SoftMEMS Xplorer product provides Micro-Electro-Mechanical System (MEMS) modeling and layout generation capabilities for the Cadence suite. SoftMEMS integrates existing third party design tools into one common design environment. The key elements of this design environment are a behavioral model to layout generator, physical layout to 3D solid model translator, a solid model to behavioral model translator. A simulation using Cadence is provided.

Cadence has very powerful import facilities available which enable, with minimal user-interaction, the seamless importing of complicated multilayer and packaging structures.Cadence enables system designers, process engineers MEMS specialists and

packaging engineers to share critical design and process information in the language most relevant to each contributor.

CST MICROWAVE STUDIO

CST Microwave Studio is a specialist tool for the fast and accurate 3D EM simulation of high frequency problems. The software is composed of 3 modules: a Broadband Time domain analysis calculation of S parameters and antennas problems, an Eigenmode calculation including modal analysis and finally a Frequency domain solver with adaptative frequency sampling.

Applications include, amongst others: Couplers, filters, planar structures, connectors, EMCand SAR problems, packages, and all kinds of antennas whose 3D millimetres ones. Antennas,antennas arrays, antenna feed systems performances could be predicted and adjusted.

The software is based on a combination of the proprietary PBA (Perfect Boundary Approximation) technique with the unbeatable efficiency of the Finite Integration method (FI).

H.WASP-NET

WASP-NET is a CAD tool for very fast 3D computational electromagnetics problems. Based on the new hybrid MM/FE/MoM/FD method, WASP-NET combines the high speed of the analytic mode-matching (MM) method with the flexibility of the space discretization finite-element (FE), method-of-moment (MoM), and finite-difference (FD) techniques.

The structure is only described by blocks association, that's why meshing is not necessary. In function of the antenna geometry, the software will combine intelligently the advantages of all four field solvers and will achieve exact accuracy and extremely high efficiency.

I.FEKO

FEKO is an electromagnetic simulator solving the Maxwell's equation in the frequency domain. FEKO is based on a full wave solution of Maxwell's equations in the frequency domain. The accurate Method of Moments (MoM) formulation is used to solve the unknown surface currents. Asymptotic techniques, Physical Optics (PO) and Uniform Theory of Diffraction (UTD), have been hybridised with the MoM in order to solve electrically large problems. The MoM has also been extended to solve problems involving multiple homogeneous dielectric bodies, thin dielectric sheets, planar multilayered media and dielectric coated wires.

J.SR3D

SR3D is a CAD tool for very fast 3D computational electromagnetics problems. This software has been developed by CNET. The software is used to analyse 3D radiating structure, calculates the electromagnetic characteristics of arbitrarily shaped structures incorporating dielectric material. The methodology is based on the Magellan code.Iterative and hybrid method have been developed and refined to analyse very large structures or to model the influence of the near environment of antennas.

K.GRASP

The GRASP9 software is the most versatile tool available for analysing general reflector antennas and antenna farms. This software is commercialised by TICRA .GRASP is widely used in the antenna reflector design (typically from 03 to 3.0 THz). The package is a general tool to handle single, dual and multi-reflector configurations (beam waveguides). GRASP9 can calculate the electromagnetic radiation from systems consisting of multiple reflectors with several feeds and feed arrays. It is even possible to analyse the interaction between various antenna systems, a requirement which is often encountered in satellite systems where several antennas may be mounted in the vicinity of each other.

L.WIPL-D PRO

WIPL-D Pro is a high-frequency electromagnetic solver based on the method of moments that can be used for the analysis of arbitrary 3D structures, formed by metals, dielectrics and wires. The code can be used for planar and 2D structures as well.

WIPL-D can be used for antenna analysis (wire antennas, horn and aperture antennas, reflector antennas, dielectric antennas, antenna arrays, micro-strip antennas) antena co-siting analysis and EMC, scatter analysis (RCS and current distribution on arbitrary shape scatterers including aircraft, vehicles, ships), microwave circuits and waveguide or other open or closed devices. WIPL-D Pro core is based on the Method of Moments, Surface Integral Equations and Surface Equivalence.Different optimization methods are available: Genetic Algorithms, Simulated Annealing, Random Search, Gradient, Simple Search, Simplex Method. Optimization can be performed as a two phase process, where any two different algorithms can be run in succession: the first one for coarse optimization and the second one for fine tuning.

III.RESULTS AND DISCUSSIONS

The following obvious and not so obvious results can be drawn from simulating antennas in different softwares. When a particular calculation is done using different softwares, they never produce the exact same result. First, these antenna design softwares aren't absolute. Secondly, even if the precision of the calculation by a certain software is high, an error in the production process of the antenna is inevitable because it is human made. Third, the elements of the antenna are usually mounted on the aluminum tube boom. When the elements of antenna are close to, or pass through a conductive substance, this electrical length would change. Thus, exactness is crucial, it is necessary to compensate the length of each element according to the boom's diameter. Fourth, even if the antenna is mounted at the top of a tower which uses

conductive substances, the antenna would be affected by the tower, mast, and so on.

Thus as illustrated above, there are many elements which have a bad influence on the performance of the antenna. Therefore, it is almost impossible to reproduce a character of the antenna as calculated. However, using a computer software, one can easily expect what kind of the antenna will be constructed. Thus, it is a big progress when it is compared with the thing before the ages when it was being gone through with by trial and error by the manual operation.

ACKNOWLEDGEMENTS

I, S.Bhavatharini sincerely thank Dr. S. Raghavan, Assistant Professor, Dept. of Electronics and Communication Engineering(ECE) from National Institute of Technology, Trichy(NITT) for introducing and sharing his thoughts and skills and his expertise in this field. I would like to thank my supervisor Mr. D. Sriram Kumar, Senior Lecturer, Dept. of Electronics and Communication Engineering(ECE), NITT for his invaluable guidance, patience and support .He has greatly fueled my enthusiasm and motivation.

REFERENCES

[1]http://www.ansoft.com/products/hf/hfss/

[2]http://edn.firstlightera.com/EN/Microsites/1/Ansoft/HFSS.htm

[3]Effective Microwave CAD tools(Ref.No 1999/064)

[4]Xiangwei Zhu, Aslam D, Yuxing Tang, stark BH, Najafi K , Microelectromechnaicall systems, Journal of volume 13, Issue 3, June 2004 Digital Object Identifier: 10.1109/JMEMES.204.8287390

[5]Xu, Fan Zhang, Shan-Liang Zhou, Lei Xu ; Nano/Micro Engineered and Molecular systems, 2007, NEMS'07

[6]Skvor. Z; Microwaves, Radar and Wireless Communication, 2000, MIKON-2000, 13th International Conference, volume 2, Issue 2000

[7] http://users.wpi.edu/~vadim/GP/GP_02-03.html